Table 5-1. Technology Screening for Soil

General Response Action	Remedial Technology Type	Process Option	Description	Effectiveness	Implementability	Cost	Potential for Retain for Further Evaluation
No Further Action	None	None	No further action to address contaminated soil.	Will not address the remedial objectives.	None	None	Yes as baseline for evaluation process
Institutional Controls	Access and Use Restrictions	Land Use Controls	Land use restriction (i.e., deed notice or restrictive covenant) is issued for properties located in the contaminated areas.	Will minimize direct exposure to the contaminants; therefore it will address remedial objectives partially. The current and future land use of the site is residential; residential, industrial, and commercial are potential uses for the Wilcox Process Area.	Implementable	Low	**Yes**
Containment	Consolidation and Capping	Clay Cap, Synthetic Membrane, or Chemical Sealant or Stabilizers	A cap is installed to cover the contaminated area to prevent direct exposure to the contamination. Different materials can be used for the cap and typical materials include clay, synthetic membranes, and chemical sealants or stabilizers. Contaminated soil can be consolidated in one area and capped.	Will prevent direct contact and exposure to the contaminated soil, although it does not remove the source of the contamination. It will address the relevant remedial objectives.	Implementable with commercially available equipment; potential worker and community exposure to dust; institutional controls will be required to protect the cap.	Medium	**Yes**
Removal	Excavation and Disposal	Excavation and Onsite Disposal	Contaminated soil is excavated and placed in a containment repository, which may consist of a bottom liner and a cap. Bottom liner may consist of, from bottom to top a impermeable liner, leachate collection layer, a protection layer overlain by excavated contaminated soil. A cap may consist of an impermeable layer, an infiltration collection layer, and soil cover and vegetation.	Will prevent direct contact and exposure to the contaminated soil by containing the contaminated materials in a repository. It will address the relevant remedial objectives.	Implementable with commercially available equipment. Potential worker and community exposure to dust during the construction, therefore dust controls will be required. Institutional controls are required to control the future land use and protect the integrity of the containment repository.	Medium	**Yes**
		Excavation and Offsite Disposal	Contaminated soil are excavated and transported to a permitted offsite facility for disposal.	Will remove the contaminated soil from the site. It will address the relevant remedial objectives.	Implementable. Potential worker and community exposure to dust during the construction and transportation for offsite disposal, therefore dust controls will be required.	Medium	**Yes**
Treatment	*In Situ* Physical, Chemical Treatment	Stabilization/Solidification	Reagents are mixed with soil to trap, treat, or immobilize contaminants. Treatment would stabilize and prevent contaminants leaching to the groundwater. Reagents may include Portland cement, bentonite, fly ash, organoclay, and activated carbon.	Will stabilize and reduce contaminants' migration, treated soil will remain onsite; administrative controls and land use restrictions will be required.	Implementable with commercially available equipment; treatability studies are required; and potential worker exposure to contaminants is present during mixing.	High. The contaminated soil is likely not hazardous, therefore the treatment is less cost effective compared to containment technologies.	No, due to high cost and lower benefit of treating the soil compared to containment technologies.
	Biological	Landfarming	Landfarming is used for the biological treatment of contaminated soil. It consists of spreading excavated contaminated soil either directly on the ground or on a membrane with an upper protective layer to prevent contaminants from migrating to the soil underneath and to the groundwater. Mixing or tilling of the contaminated soil is normally required to blend nutrients/amendments, and distribute moisture to promote biodegradation of the contaminants. Periodical watering is also required to provide optimal condition for microbial activities.	Landfarming is typically applicable to nonvolatile and semi-volatile compounds. Biodegradation of PAHs becomes more difficult as the number of aromatic rings increase. Therefore landfarming typically is not considered to be effective for treating PAHs that contain more than four rings, i.e., benzo(a)pyrene. It is not certain if landfarming will be effective for treating lead in soil with data currently available.	Implementable, however it may take a long period of time depending on biodegradation process in the soil.	Low	No due to ineffectiveness with inorganics
		Phytoremediation	Phytoremediation is a process that uses plants to remove, transfer, stabilize, and destroy contaminants in soil and sediment. The mechanisms of phytoremediation include enhanced rhizosphere biodegradation, phyto-extraction (also called phyto-accumulation), phyto-degradation, and phyto-stabilization.	Under controlled experimental settings, a variety of plants have been shown to remediate both lead and benzo(a)pyrene in surface soil. Treatability and pilot studies would be required to determine the effectiveness of phytoremediation at the site.	Technology is potentially implementable with pilot study. However, climate, site soil type, and / or lithology characteristics may not be conducive to needed plant/tree species. Limited species are effective with metals. It may also require a long period of time compared to other technologies depending on season and temperature.	Medium	No due to the concern on implementability

Table 5-1. Technology Screening for Soil

General Response Action	Remedial Technology Type	Process Option	Description	Effectiveness	Implementability	Cost	Potential for Retain for Further Evaluation
Treatment	*Ex situ* Physical, Chemical Treatment	Excavation and Chemical Oxidation	Oxidizing agents (Fenton's reagent, permanganate, and ozone) are added into the excavated soil to promote abiotic destruction of contaminants.	Chemical oxidation will make lead and other metals become soluble, potentially causing mobilization of metals to groundwater.	Implementable	High. Can be cost prohibitive if the soil contains high organic matter.	No, due to the concern for mobilizing lead to groundwater and high cost.
		Excavation and Soil Mixing and Stabilization/Solidification	Reagents are mixed with excavated soil by a mechanical mixing device to trap, treat, or immobilize contaminants. Treated soil may be placed onsite for future applicable land use. Reagents may include Portland cement, bentonite, fly ash, organoclay, and activated carbon.	Will stabilize and reduce contaminants' migration, treated soil will remain onsite; administrative controls and land use restrictions will be required.	Implementable with commercially available equipment; treatability studies are required; and potential worker exposure to contaminants is present during excavation and mixing.	High. The contaminated soil is likely not hazardous, therefore the treatment is less cost effective compared to containment technologies.	No, due to high cost and lower benefit of treating the soil compared to containment technologies.
		Excavation and Soil Washing	Contaminants in soil are desorbed by using a solution of leaching agent, surfactant, pH-adjustment, or chelating agent to help remove the contaminants and fine materials on which the contaminants absorbed.	Will address the remedial objectives by removing the contaminants from the soil .	Complex process and produce a large quantity of process water that requires treatment. Acid reagent may be used to remove lead from soil, which increase the health and safety concern during the implementation.	High	No due to the concern on implementability.
		Excavation and Thermal Treatment	Heat is applied to the excavated soil to increase the volatility of the contaminants. An off-gas treatment will be used to treat the volatilized contaminants. *Ex situ* thermal treatment technologies include hot gas decontamination, incineration, thermal desorption, and vitrification, which use a high temperature to immobilize contaminants and produce non-toxic vitreous stabilized products.	Will destroy or remove and recover the contaminants, so it will address the remedial objectives.	Not readily implementable, treatability studies required; significant materials handling; specialized equipment and operators; extended construction/ treatment period (6-7 months); and viscous nature may require pre-treatment. If treated soil is placed onsite, beneficial use of the treated soil shall be studied for future land use, and institutional controls may be required.	High; not cost effective for the relatively low concentrations of the contaminants at the site.	No, due to complex implementation and cost.

Notes:
PAH = Polycyclic aromatic hydrocarbon

TABLE 7-1
EVALUATION OF SOIL REMEDIAL ALTERNATIVES

Evaluation Criteria	S-1 - No Further Action	S-2 - Soil Excavation and Offsite Disposal	S-3 - Soil Excavation and Onsite Containment Repository	S-4 - Soil Excavation, Onsite Consolidation, and Capping
1. Overall Protection of Human Health and the Environment				
How Alternative Provides Human Health and Environmental Protection	This alternative would not be protective of human health or the environment.	This alternative would protect human health and the environment by removing the contaminated soil from the site and transporting and disposing of it in an offsite permitted facility.	This alternative would protect human health and the environment by containing the contaminated soil in a containment repository constructed onsite.	This alternative would protect human health and the environment by consolidation and capping of the contaminated soil.
2. Compliance with ARARs				
Compliance with ARARs	No Action, so no rules apply.	Yes	Yes	Yes
3. Long Term Effectiveness and Permanence				
a. Magnitude of Residual Risk	Not applicable.	This alternative would permanently eliminate the risks and exposure to the soil contaminants from the site.	Once remediation is complete, because the contaminated soil still remains onsite, although contained, institutional controls and monitoring will be implemented to protect the remedy. Therefore, the residual risk would be low.	Similar to Alternative S-3, because the contaminated soil still remains onsite, although capped, institutional controls and monitoring will be implemented to protect the remedy. Therefore the residual risk would be low. Groundwater monitoring will confirm the capped contaminated soil does not leach to the groundwater.
b. Adequacy and Reliability of Controls	Not applicable.	Removal of COC-impacted soil would be a permanent solution with long-term effectiveness.	Containment of COC-impacted soil with monitoring and institutional controls of the containment would be reliable to ensure long-term effectiveness of the remedy.	Consolidating and capping COC-impacted soil with monitoring and institutional controls of the cap would be reliable to ensure long-term effectiveness of the remedy.
4. Reduction of Toxicity Mobility, and Volume Through Treatment				
a. Treatment Process Used and Materials Treated	Not applicable.	This alternative involves no treatment processes.	This alternative involves no treatment processes.	This alternative involves no treatment processes.
b. Amount of Hazardous Materials Destroyed or Treated	Not applicable.	The COCs will not be destroyed or treated.	The COCs will not be destroyed or treated.	The COCs will not be destroyed or treated.
c. Degree of Expected Reductions in Toxicity, Mobility, and Volume	Not applicable.	This alternative will reduce toxicity, mobility, and volume of the COCs with respect to onsite conditions because the contamination will be physically removed from the site, not treated.	This alternative will reduce mobility of the COCs with respect to onsite conditions because the contamination will be physically removed and placed in a containment/capped area. The toxicity and volume remain unchanged.	This alternative will reduce mobility of the COCs with respect to onsite conditions because the contamination will be physically removed and placed in a containment/capped area. The toxicity and volume remain unchanged.
d. Degree to Which Treatment is irreversible	Not applicable.	No treatment processes are used under this alternative.	No treatment processes are used under this alternative.	No treatment processes are used under this alternative.
e. Type of Residuals Remaining After Treatment	Not applicable.	No treatment processes are used under this alternative.	COC-impacted soil will remain onsite after remedial action.	COC-impacted soil will remain onsite after remedial action.

Evaluation Criteria	S-1 - No Further Action	S-2 - Soil Excavation and Offsite Disposal	S-3 - Soil Excavation and Onsite Containment Repository	S-4 - Soil Excavation, Onsite Consolidation, and Capping
5. Short Term Effectiveness				
a. Protection of Community During Remedial Actions	Not applicable.	There would be some short term risk to the community during excavation and transportation of contaminated soil (i.e., dust generation and trucks transporting waste from the site).	There would be some short term risk to the community during excavation and transportation of contaminated soil (i.e., dust generation and trucks transporting waste from the site).	There would be some short term risk to the community during excavation and transportation of contaminated soil (i.e., dust generation and trucks transporting waste from the site).
b. Protection of Workers During Remedial Actions	Not applicable.	Implementation of this alternative would pose a minimal risk to remedial workers or the environment as long as proper health and safety procedures are followed.	Implementation of this alternative would pose a minimal risk to remedial workers or the environment as long as proper health and safety procedures are followed.	Implementation of this alternative would pose a minimal risk to remedial workers or the environment as long as proper health and safety procedures are followed.
c. Environmental Impacts	Not applicable.	Engineering and administrative controls during excavation and removal activities would minimize impacts to the environment. Stormwater pollution prevention procedures will be established to prevent the surface water from being impacted.	Engineering and administrative controls during excavation and removal activities would minimize impacts to the environment. Stormwater pollution prevention procedures will be established to prevent the surface water from being impacted.	Engineering and administrative controls during excavation and removal activities would minimize impacts to the environment. Stormwater pollution prevention procedures will be established to prevent the surface water from being impacted.
d. Time Until Remedial Action Objectives are Achieved	No RAOs achieved.	Excavation and offsite disposal can be achieved in a very short time frame, typically 6 months to a year.	Excavation and onsite containment repository can be achieved in a relatively short time frame, typically 6 months to a year.	Excavation and onsite capping can be achieved in a relatively short time frame, typically 6 months to a year.
6. Implementablility				
a. Ability to Construct and Operate the Technology	Not applicable.	Removal of soil is easily implemented with conventional construction equipment, and no specialized work force is required.	Removal of soil and containment is easily implemented with conventional construction equipment, and no specialized work force is required.	Removal of soil and capping is easily implemented with conventional construction equipment, and no specialized work force is required.
b. Reliability of the Technology	Not applicable.	Excavation under this alternative is a widely proven technology that is reliable at removing COCs.	The technologies used in this alternative, excavation and capping, are reliable; and quality control and quality assurance for containment construction shall be followed to protect the remedy reliability.	The technologies used in this alternative, excavation and capping, are reliable; and quality control and quality assurance for containment construction shall be followed to protect the remedy reliability.
c. Ease of Undertaking Additional Remedial actions, if Necessary	Not applicable.	Additional remedial actions would be easily implemented if needed under this alternative (i.e., additional excavation).	Additional remedial actions would be easily implemented if needed under this alternative (i.e., additional excavation), and revised design may be required.	Additional remedial actions would be easily implemented if needed under this alternative (i.e., additional excavation).
d. Ability to Monitor Effectiveness of Remedy	Not applicable.	Confirmation samples will be easy to collect to ensure complete removal of the contaminated soil.	The effectiveness of soil excavation and containment will be easily monitored. Activities include confirmation sampling during the excavation and groundwater monitoring and periodical inspection of the repository.	The effectiveness of soil excavation and capping will be easily monitored. Activities include confirmation sampling during the excavation and groundwater monitoring and periodical inspection of the cap.
e. Ability to Obtain Approvals from Other Agencies	Not applicable.	Approvals from other agencies would likely be obtained.	Approvals from other agencies would likely be obtained.	Approvals from other agencies would likely be obtained.
f. Availability of Offsite Treatment, Storage, and Disposal Services and Capacity	Not applicable.	Offsite disposal is readily available for soil disposal.	Not required.	Not required.
g. Availability of Necessary Equipment and Specialists	Not applicable.	Equipment necessary to implement this remedy is readily available; no specialized equipment is required.	Equipment necessary to implement this remedy is readily available; no specialized equipment is required.	Equipment necessary to implement this remedy is readily available; no specialized equipment is required.
h. Availability of Prospective Technologies	Not applicable.	The technology is readily available.	The technology is readily available.	The technology is readily available.
7. Cost				
A. Total Present Worth Value	**$0**	**$3,484,412.49**	**$6,592,303.22**	**$4,809,892.62**

Notes:
ARAR = Applicable or relevant and appropriate requirement.
COC = Contaminant of concern.
RAO = Remedial Action Objective.
O&M = Operation and maintenance.

TABLE 7-2
COMPARATIVE ANALYSIS OF SOIL REMEDIAL ALTERNATIVES

Criteria	Alternative S-1	Alternative S-2	Alternative S-3	Alternative S-4
	No Further Action	**Soil Excavation and Offsite Disposal**	**Soil Excavation and Onsite Containment Repository**	**Soil Excavation, Onsite Consolidation and Capping**
Overall Protection of Human Health and the Environment	▼	▲	▲	▲
Compliance with ARARs	Not applicable	▲	▲	▲
Long-Term Effectiveness and Permanence	▼	▲	▼	▼
Reduction of Toxicity, Mobility, or Volume through Treatment	▼	▼	▼	▼
Short-Term Effectiveness	▲	▼	▼	▼
Implementability	▲	▲	▲	▲
Total Cost (30-Year Present Worth)	**$0**	**$3,356,649.95**	**$6,596,518.00**	**$4,814,108.00**

Notes:
ARAR = Applicable or Relevant and Appropriate Requirements.
▲ = In comparison with other alternatives, complies well with criteria.
▼ = In comparison with other alternatives, does not comply as well with criteria.